Space Weather Technical Forecast

Issued on Wednesday, 15 March 2023 at 13:49 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Minor/Moderate Geomagnetic storms and chance of a G3/Major Geomagnetic storm due to combined effects of possible further glancing CMEs and CH84 enhancement on Days 1-2 (15-16 March). Slight but diminishing chance of S1/Minor Radiation storm Days 1-2.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low or Very Low over the past 24 hours with occasional C-class flares. The peak flare a C1.2 at 14/2226UTC from AR325. There are currently nine sunspot regions on the visible disc. These are a mixture of small, mature spots with a couple of small but emergent/developing regions. All spots however, have remained relatively magnetically simple.
No Earth directed CME's have been observed in the past 24 hours.

Solar Wind / Geomagnetic Activity: Solar wind increases reflected the arrival of a CME at DSCOVR around 15/0350UTC, with speeds observed at L1 rising sharply from 410 km/s to around 550 km/s. Winds have since gradually declined to around 480 km/s. The density has been predominantly above average, but saw a sudden jump around 15/0400UTC from 12ppcc to a peak of 35ppcc at 15/0404 UTC. The total IMF strength was weak to moderate, increasing sharply around 15/0400UTC to strong, with a peak of 26nT at 15/0502UTC. IMF strength has since returned to moderate. The north-south component was variable fluctuating between +16/-10nT, but was often negative until 15/0400UTC, after which time it has been predominantly positive. The Phi angle was mostly positive (away from the Sun) other than between 14/1850-15/0200UTC when occasional spells of negative (towards the Sun) developed. Geomagnetic activity was Unsettled to Active (Kp 3-4), with a G1/Minor Storm interval observed.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16, rose above the S1 level, likely due to the ongoing effects from the significant far-sided eruption early on 13 Mar, with a peak of 22pfu at 15/0425UTC. Proton flux dropped below the S1 threshold around 15/0600UTC and has been on a downward trajectory. The high energy electron flux (greater than 2MeV) has been at moderate to background levels, with a peak of 505pfu at 14/1450UTC. The associated 24 hour Electron fluence has remained below Active on a largely flat to declining trend. At 15/0001UTC the observed fluence was 7.13e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to continue Low or Very Low, with a slight chance of an isolated M-class flare. In addition to the current sunspots on the Earth-facing disc, new regions are expected to rotate onto the visible disc during the forecast period. There are number of filaments on the disc, which should any erupt, could be another source of C-class flares.

Solar Wind / Geomagnetic Activity: Further glancing CME impacts are possible through 15 March, due to filament eruptions that occurred 10-13 March. These are all low confidence, however any combined effect could give a larger geomagnetic response than normally expected from such glancing impacts. Solar winds are expected to remain at or close to elevated levels

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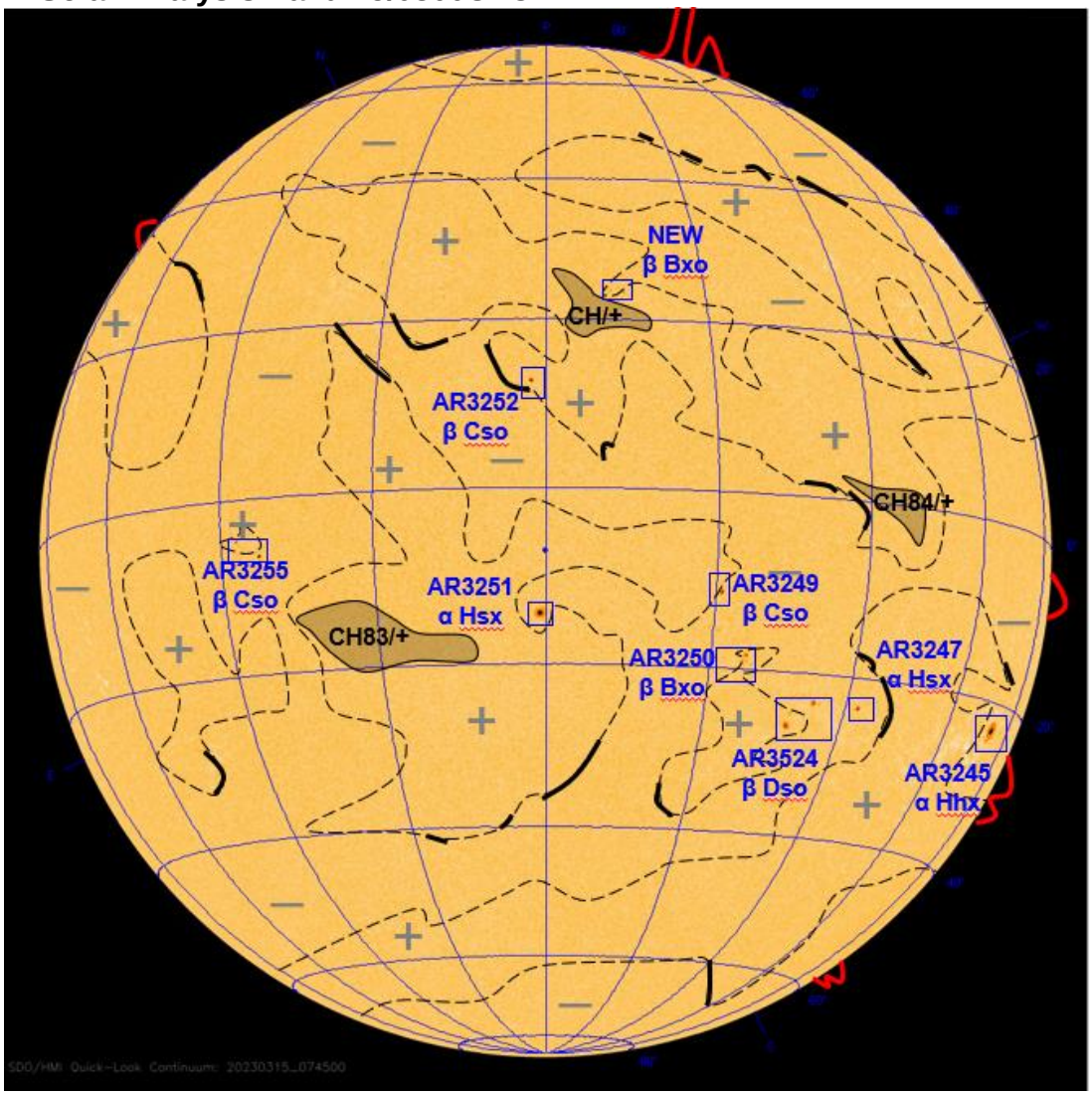
throughout Days 1-2 with additional weak enhancement possible from the arrival of a coronal hole high speed stream on Day 1, winds then expected to decline but remain at slightly elevated levels. Geomagnetic activity will initially fluctuate between Unsettled to Active, with the combined influence of CME and HSS expected to bring G1/G2 Minor/Moderate geomagnetic storms and a chance of a G3/Strong storm interval on Days 1-2. Activity easing to mainly Quiet by 17 March.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux, as observed by GOES16, is expected to remain at background levels through the period, with a slight chance of S1/Minor storming if any further large far-sided eruptions occur. The high energy electron flux is expected to persist at Background to Moderate levels, with faster winds from CH84/+ or any CME likely to continue suppressing flux. Flux levels are likely to rise more persistently towards Moderate by the end of the period, with a chance of reaching High levels by Day 4 (18 Mar). The associated 24 hour electron fluence is expected to persist at below the Active level.

Figure 1. Solar Analysis Valid 15/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:
Solar winds increased sharply at 15/0428UTC to elevated levels and are currently around 510 km/s. This increase is likely to be associated with the arrival of a CME that left the Sun on 10 Mar.

Further CME glances are possible on Days 1-2 (15-16 Mar) from the combined influence of filament eruption CMEs which left the Sun on 12 and 13 Mar. Although, these CMEs are expected to pass largely north and ahead of Earth.

Solar winds are expected to remain at or close to elevated levels throughout Days 1-2 with additional weak enhancement possible from the arrival of a coronal hole high speed stream. This is not favoured for a strong connection around the March equinox due to the Russell Mcpherron effect. The arrival of this HSS may be masked on the solar wind trace by the signal of CMEs. Winds are expected to gradually decline by Day 3 (17 Mar), although likely remaining at Slightly Elevated levels throughout the remainder of the period.

Confidence in the impacts from these events is low, however given the number of CMEs potentially arriving in a period of 24 hours cumulative impacts may result in a stronger geomagnetic response during Days 1-2 than would normally be expected for such events.

Geomagnetic activity will fluctuate between Unsettled to Active, with the combined influence of CME and HSS expected to bring G1/G2 Minor/Moderate geomagnetic storms and a chance of a G3/Strong storm interval on Days 1-2. Activity will ease to mainly Quiet by Day 3 (17 Mar).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	80	30	1	1
Strong	G3	No	30	10	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
11/0102	Partial	Filament	SW	495 km/s	Missing	Possibly observed early 15 Mar
12/2340	Partial	Filament	SE	760 km/s	15/1800 +/- 6hrs	Glancing impact
13/1319	Partial	Filament	N	1330 km/s	1500/1200 +/- 9hrs	Possibly observed early 15 Mar

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Figure 2: Trace of L1 Solar Wind speeds showing sudden increase and subsequent decline

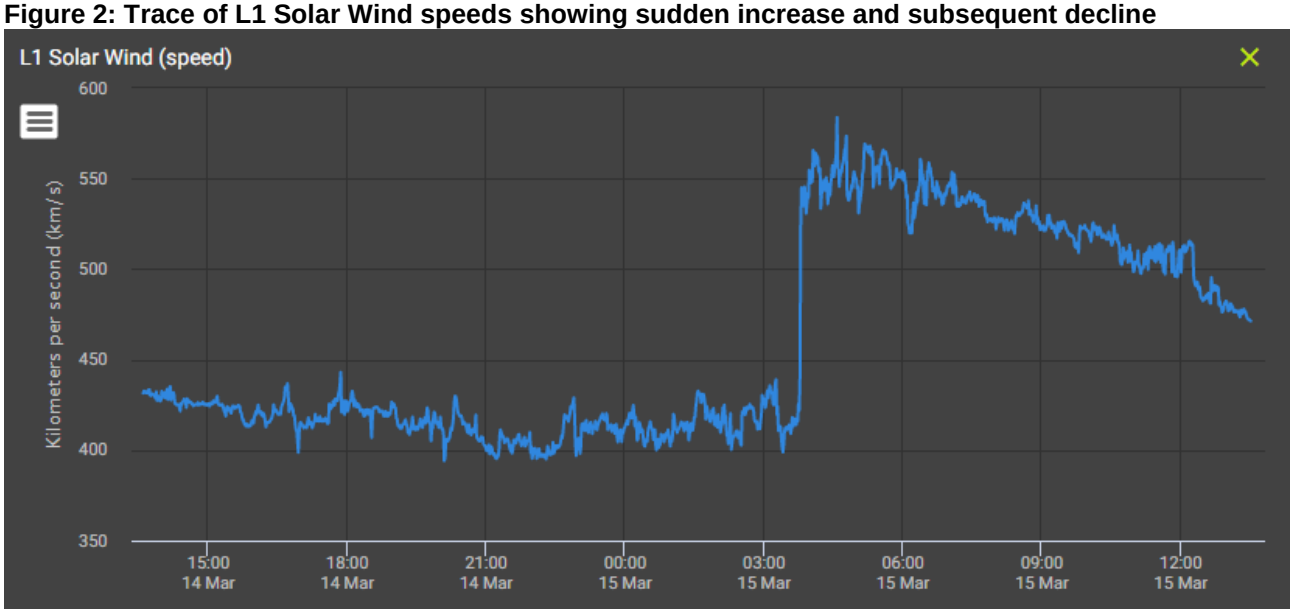
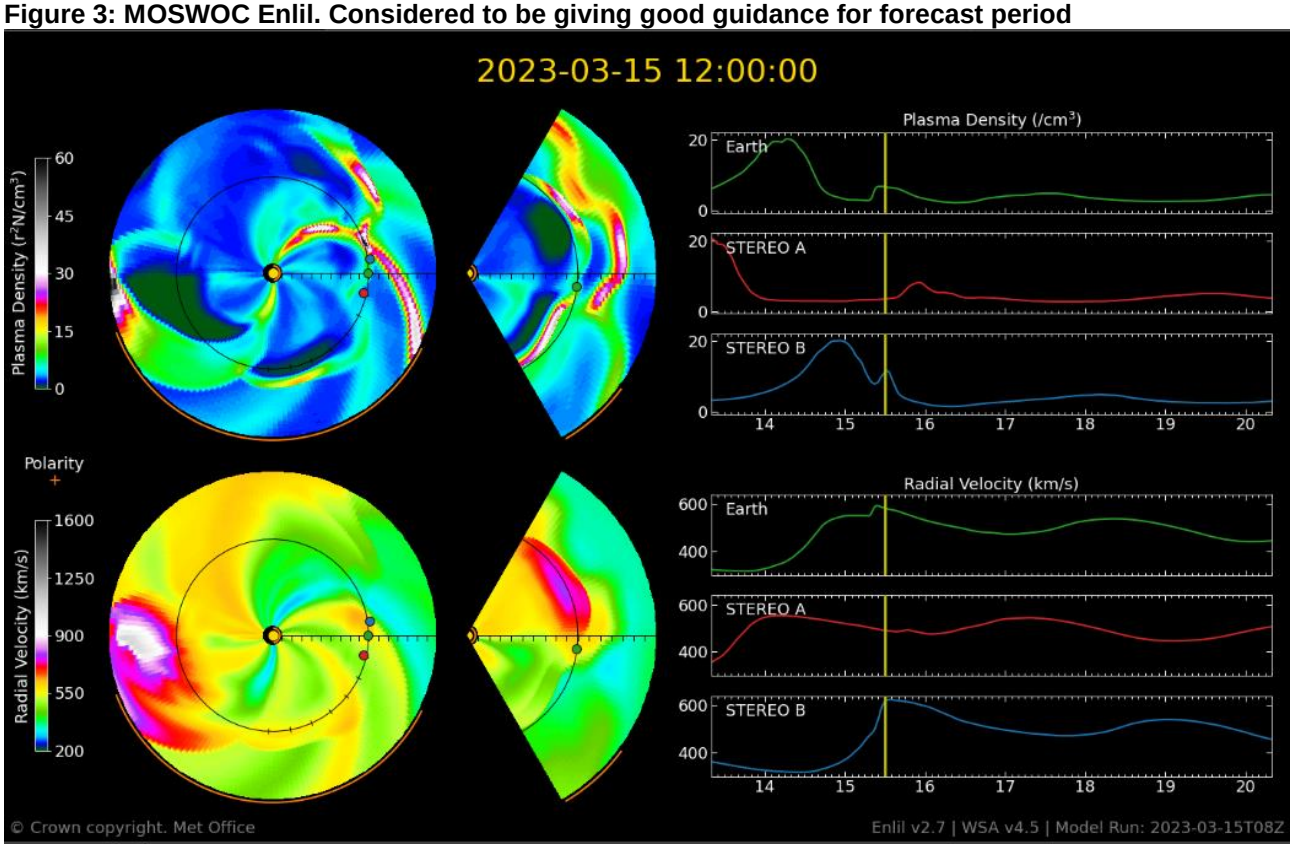


Figure 3: MOSWOC Enlil. Considered to be giving good guidance for forecast period



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Radio Blackouts - X-Ray Flares:
Solar activity has been Low or Very Low over the past 24 hours with occasional C-class flares. The peak flare a C1.2 at 14/2226UTC from AR325.

There are currently nine sunspot regions on the visible disc. These are mostly small, mature spots which have shown limited growth over the past 24 hours. The proliferation of some minor spots has changed the magnetic complexity of several regions, with the most complex region being AR3254/Dso in the SW hemisphere. All spots however, remain relatively magnetically simple at present. In addition to the spots, there are number of filaments on the disc, which should any erupt, could be another source of C-class flares.

Solar activity is expected to continue to be Low or Very Low, with a slight chance of an isolated M-class flare. New regions are expected to rotate onto the visible disc during the forecast period, leading to a slight increase in the probability of associated M-class flares, but this is low confidence.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	10	5	5	10
Very Active	R3 to R5 X Class	No	1	1	1	1

Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux increased to above the S1 level, likely due to the ongoing effects from the significant far-sided eruption early on 13 Mar, with a peak of 22pfu at 15/0425UTC. Proton flux dropped below the S1 threshold around 15/0600UTC and has been on a downward trajectory. This is likely to be in response to the arrival of a CME at Earth earlier on Day 1 (15 Mar), which is acting to shield the Earth environment from proton storm effects.

Given the simplicity of the sunspots currently on the disc, no further enhancements are expected. There is a slight chance of values increasing to give S1/Minor storming during Days 1-2 (15-16 Mar), but the trend is for values to remain at background levels, unless any further large far-sided eruptions occur.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	Yes	20	20	1	1
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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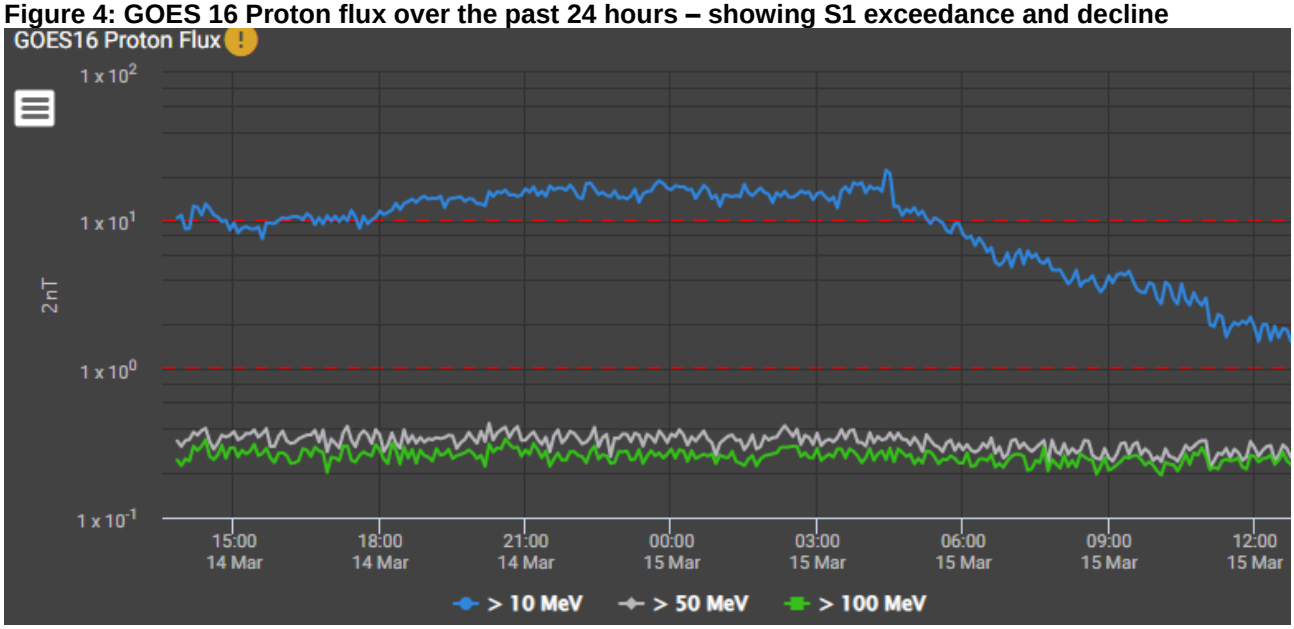
Figure 4: GOES 16 Proton flux over the past 24 hours – showing S1 exceedance and decline



High Energy Electrons Event (≥ 2MeV):
The high energy (greater than 2 MeV) electron flux at GEO, as observed by GOES-16, is expected to persist at Background to Moderate levels, with the arrival of a CME early on Day 1 (15 Mar) acting to suppress flux. The arrival of any further CMEs during Days 1-2 (15-16 Mar) and/or the high speed stream from CH84/+ will likely continue to suppress flux. Flux levels are expected to recover towards the end of the period as the residual influence from any CMEs and the weak HSS wanes. Flux levels likely to rise to Moderate by the end of the period, with a chance of reaching High levels by Day 4 (18 Mar).

The associated 24 hour electron fluence is expected persist at below the Active level, gradually trending towards the Active threshold during Days 3-4 (17-18 Mar), with only a slight chance of the Active threshold being crossed. REFM is currently considered to be giving good guidance.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	10	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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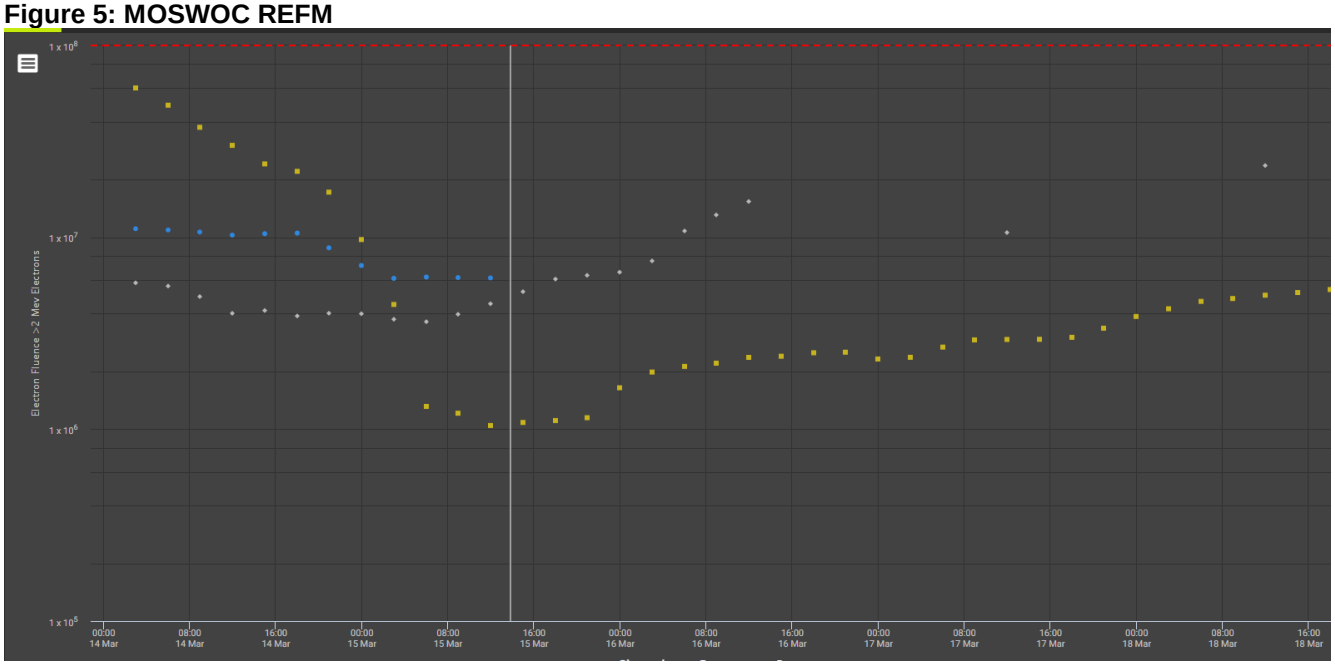
Figure 5: MOSWOC REFM



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